Report of the

Senior Review of

Origins and Structure and Evolution of the Universe

MISSION OPERATIONS AND DATA ANALYSIS (MO&DA) PROGRAMS

June 27-29, 2000

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Introduction

The Astrophysics Senior Review panel met June 27-29, 2000 to review requests from ten missions and six data centers for MO&DA funding for the FY01-FY04 time frame. The choices were difficult: The combined requests for support appreciably exceeded available funds; the merits of extending the lifetime of astronomical missions had to be weighed against the importance of expanding the archives designed to safeguard and provide access to the data these missions had generated; some missions had not yet been launched, while others were nearing the end of a productive run; some missions were requesting a significant fraction of available resources, while others were asking for a much smaller share.

Given the scope and variety of these choices, the panel found no simple metric to assess the scientific cost effectiveness of the various astronomical missions and data centers, i.e. their scientific value per dollar. However, the written proposals submitted by the various groups, their oral presentations, and their responses to questions from the panel did provide a sound basis for assessment. An poll of panel members conducted by secret ballot after the conclusion of presentations showed remarkable unanimity on the relative scientific merits of the different missions and data archives, and laid the foundations for our recommendations.

Overview of Archive Centers

Most significant, perhaps is the panel's unanimity in urging strong support for data archive centers. We saw no other way of assuring that the enormous data troves now being gathered by increasingly sophisticated astronomical missions in space be made rapidly accessible for scientific analysis. Nor could we find alternatives for adequately safeguarding these data so that future generations of astronomers might combine them with information yet to be gathered to gain far deeper insights into the nature of our Universe.

Despite our appreciation of the services the data archives offer, we see a clear need for further thought about their design. We recognize the oft-mentioned interest in combining the resources offered by available data centers to offer a desk-top view of the sky as seen through every conceivable instrument. However we also appreciate the complexities of the issues involved: The data sets generated by different types of observatories are highly varied, and cannot be effectively archived without appropriate expertise. Gamma-ray observatories, cosmic ray detecting stations, and ground-based optical facilities, all generate products marred by a variety of natural and instrumental sources of "noise". The effects of these varied disturbances can often be minimized, but only by astronomers thoroughly acquainted with peculiarities of the instruments that were used in gathering the data and the natural environment that produced the extraneous noise. Setting up a useful system may therefore hinge on the coordination of efforts at a number of different centers, each with its own experts and areas of expertise, but each also willing to work toward a common goal.

As part of this Senior Review, a number of outside reviewers were asked to compare the relative merits of NASA's various data archives, evaluate their utility and offer comments. The panel agrees with the assessments provided in the mail-in reviews, and recommends a high level of cooperation to i) streamline data analysis tools wherever possible; ii) eliminate duplication of effort; and iii) provide transparent access to all of NASA's data bases currently handled by the different centers.

Providing guidance on a specific path that may lead to the establishment of a coherent data system is clearly beyond the scope of the present panel. However, we recommend that NASA continue an examination of the services a coherent data system could realistically be expected to provide, and of the ways in which such a system might be established and maintained at the cutting edge of available computational and communications technologies. Factored into these considerations would have to be the relative costs of providing this service, as compared to the costs of operating astronomical missions. These are important considerations. They deserve careful scrutiny but also require early decisive action, since the data centers are rapidly evolving and require escalating resources.

Proposal Format

We reiterate a recommendation of the Senior Review conducted in 1998. Proposals submitted on behalf of missions and archives must be made shorter. We found that a proposal length of thirty pages is out of proportion to the size of projects reviewed here. We urge that a new limit of ten to fifteen pages per proposal be set for the Senior Review of 2002. The many unsolicited endorsements that a number of proposals included this time should be eliminated; the panel found them unconvincing.

A particularly useful feature that should continue to be incorporated in all proposals is a uniform budget presentation that provides easy overview and comparisons. Labor, major equipment, and other expenses for both the "baseline" and the "optimum" requests should be explained in sufficient detail to determine the incremental cost of each proposed task. Especially helpful to a head-to-head comparison is full cost accounting. Several of the proposals showed only funding requested from this Senior Review, without also exhibiting funding they were receiving from other sources. This made an evaluation in terms of science per dollar very difficult.

Of special help to the panel would be the inclusion of a full list of all acronyms with their designations spelled out. Inclusion of such designations on first use of an acronym in the text is not sufficient. The meanings of the individual acronyms are quickly forgotten in a proposal that packs several dozen into just a few pages.

Mission Assessments

2MASS

The Two Micron All Sky Survey (2MASS) is a mission to carry out a digital imaging survey of the entire sky in three near infrared wavelengths (J: 1.25 microns H: 1.65 microns K: 2.2 microns). A complete digital atlas containing 4 million calibrated images and accurate photometry and astrometry for over 300 million point-like sources and 2 million resolved sources will be produced.

Strengths

The 2MASS effort has been executed well and will finish its mission on budget. IPAC has an excellent track record in delivering a high quality, complete data product. It will serve as a high quality database for the entire astronomical community.

Weaknesses

The proposal did not make a clear case for surveying the entire sky before starting the final data processing.

Recommendation

This effort should be strongly supported. We recommend completion of the planned uniform reprocessing of the full-sky survey, and timely completion of the catalog, especially for planning purposes for SIRTF and other missions.

RXTE

RXTE provides the unique capabilities of broad energy coverage, large collecting area, and small deadtime, thus providing high count rates and microsecond time resolution. This makes it possible to investigate fundamental problems associated with the dynamics of astrophysically compact objects. These capabilities are not duplicated by either Chandra, XMM or any future planned mission.

Strengths

RXTE continues to produce new and exciting results in the study of compact objects. Recent results include: (1) progress in understanding the kilohertz QPO mechanism, (2) the discovery of magnetars, (3) determining new constraints on the geometry and physics of AGN (4) the discovery of the first evidence for strong – field general relativistic effects, and (5) progress on determining the equation of state for neutron star matter.

Weakness

RXTE continues to experience a slow degradation in the sensitivity of the PCA detectors.

Recommendation

New and exciting results continue to be produced by RXTE. We recommend continued support for the operation of this mission.

XMM-Newton

XMM-Newton has the largest collecting area to date for a focusing X-ray telescope (0.1-12 keV), and the instrument has excellent imaging and spectral capabilities. It offers two imaging instruments (in EPIC), high resolution spectroscopy (RGS), and optical monitoring capabilities (OM). Launched in December 1999, it is expected to make fundamental contributions in many branches of astronomy.

Strengths

The combination of sensitivity, spectral capabilities, and field of view make this the instrument of choice for a range of studies. Important results are already emerging for galaxies, galaxy clusters, active galaxies, stars, supernova remnants, and a range of other targets.

The time allocation committees have fulfilled the promise that makes this a telescope open to the world and US observers have been welcome and successful. US participation is highly leveraged.

The instruments are performing well and the team has worked around the problems that can arise due to low energy particles present in parts of the orbit.

Weaknesses

Access to Cal/PV data has been limited.

The calibration and data processing systems need software development.

Recommendation

This spacecraft represents a major investment for European space astronomy, and considering the European openness toward US investigators, the US should assist in the optimization of this mission. We recommend, in order of priority: (1) Enhancement of RGS activities (calibration, mission operations, and software development) and XMM-specific analysis software development (at the GOF and Carnegie Mellon University). (2) An augmentation of Guest Observer funds (3) Adequate support for the infrastructure to enable archival research (4) In-Guideline level of support for the other activities, including the Optical Monitor, support for Mission Scientists, and the Education/Outreach program.

HETE-2

The High Energy Transient Explorer 2, HETE-2, satellite is devoted to the study of gamma-ray bursts (GRBs) using soft X-ray, medium X-ray and gamma-ray instruments mounted on a compact spacecraft. HETE-2 is expected to launch in 2000.

Strengths

HETE-2 is using an innovative concept to provide accurately localized positions of GRBs to the international scientific community within seconds of their discovery. The satellite team has very successfully established a network of twelve Burst Alert Stations which provides a 90% temporal coverage for GRB follow-up observations across the globe. During its eighteen month mission, HETE-2 will enhance the number of known GRB redshifts by at least a factor of 2 and provide invaluable input towards the determination of the GRB luminosity function. Furthermore, HETE-2 is uniquely equipped to detect afterglows of short GRBs for the first time, thus probing the properties of a potentially different GRB class.

The requested extended HETE-2 mission will provide a larger sample of bursts by a factor of 2 and scientific and programmatic continuity in the field until the launch of Swift, a GRB dedicated MIDEX mission. The six month suggested overlap between HETE-2 and Swift is necessary to afford instrument cross-calibration. In addition, a HETE-2 extended mission is cost effective and will provide a safety net for potential Swift launch delays and/or failure.

Weaknesses

The continuity afforded during an extended mission will improve the quantity of data but is not likely to lead to new breakthroughs.

Recommendation

We recommend an extended lifetime mission for HETE-2 through 2004. The HETE-2 scientific team should ensure heritage of their experience, with their world-wide network of support and their operating system, to the Swift team. During the extended mission, we recommend that all data products of HETE-2 be immediately available to the public.

FUSE

The satellite is obtaining high resolution spectra from the Lyman limit to 119 nm. It started routine observations on 1 December 1999 and has carried out science observations for 26% of the time since. In Cycle 1, the FUSE team received 3/4 of the observing time, as planned. This fraction will change to 1/3 of the time for the team in Cycle 2. Beyond the prime mission, 100% of time will be allocated to guest investigators. The main programs of the team are (a) the determination of the interstellar abundance of deuterium as a test of Big Bang nucleosynthesis; (b) the investigation of the hot ISM and IGM, especially by means of the O VI absorption doublet, and (c) the use of the numerous lines of H_2 to diagnose the physical conditions of the molecular ISM.

Strengths

There is no other mission planned in the FUSE wavelength band, which contains many important astrophysical lines. The instruments are working well.

FUSE has good sensitivity. It can investigate the IGM at moderate or even moderately high red shifts. It can observe luminous stars in the Magellanic Clouds, stellar chromospheres, and planetary atmospheres. These capabilities will make it valuable to a broad range of astronomers.

The forest of H_2 lines allows a diagnosis of physical conditions of the ISM in a wide variety of contexts.

Good pointing stability allows data acquisition from faint targets.

Weaknesses

There are bursts of noise in some of the data. It is difficult for the general user to remove the effects of these bursts from the spectra unless access to the pipeline for data processing is available.

Recommendation

We recommend that the mission be extended for an additional 24 months beyond the prime mission. We encourage continued efforts to improve pipeline data processing and data products. The goal for the pipeline should be to deliver cross-orbit coadded data at the full resolution of the instrument with all instrumental artifacts removed, including “bursts”.

ISO

The ESA Infrared Space Observatory (ISO), launched in November 1995, completed its data acquisition phase in April 1998. ISO was an infrared observatory in space, providing large improvements in angular resolution and spectral resolution, and several orders of magnitude improvement in sensitivity over previous space astronomy missions. ISO was a "pathfinder" observatory that broke new scientific ground for future infrared observatories such as SIRTF, SOFIA and NGST.

Strengths

The ISO mission has addressed many fields of research, including formation of stars and planetary systems, the formation and evolution of galaxies, and the physics and chemistry of the interstellar medium. ISO scientific results impact most areas of astronomical research from solar system studies to cosmology.

All of the ISO mission data are now public. The ISO archives promise to be of great value to the entire astronomical community. The high-resolution spectra produced by this mission will remain unique for a long time, and will serve as pathfinders for SOFIA and SIRTF.

The ISO mission has been used by and has influenced the research of a large group of US astronomers. US participation in the openly competed time available through the guest investigator program was very high.

Weaknesses

Though the data acquisition phase of the ISO mission is over, work continues on data reduction and archiving. The complex on-orbit behavior of the ISO detectors has made the calibration process difficult and caused it to extend well beyond previous plans. ISOPHOT measurements have been especially hard to calibrate. The ISO teams continue to improve the pipeline processing and calibration of the science data.

Most instruments were less sensitive than initial expectations.

Recommendation

The high quality and importance of ISO observations justifies support for completion of the data reduction and preparation of a high-quality archive. We recommend support in FY '01 to make the results of final ISO processing available to the US community, conduct a final ISOPHOT workshop, integrate ISO data access into IRSA, and complete documentation of the ISO data.

SWAS

The Submillimeter Wave Astronomy Satellite (SWAS) is designed to study several important spectral lines in the submillimeter region, to investigate the role of cold water and molecular oxygen in star formation and to observe neutral carbon and carbon monoxide. The mission has performed well since launch in December 1998. On-orbit performance meets or exceeds design specifications and there is no evidence of degradation of the critical components.

Strengths

SWAS has made several significant discoveries. It found that the water abundance in the interstellar medium is very variable. Observations of several giant molecular clouds indicate that the water abundance in these objects is more than an order of magnitude lower than the predictions of models of the interstellar medium. The water abundance in 'translucent clouds', observed in absorption toward Sgr B2, is approximately as predicted, as is the water abundance in regions that have been compressed by shock waves associated with protostellar outflows. SWAS has also detected water in the circumstellar envelopes of evolved stars, in the atmospheres of Jupiter, Saturn, Mars, and in Comet Lee.

It has been predicted that molecular oxygen plays a major role in the chemistry of molecular clouds. SWAS has not yet detected molecular oxygen in the interstellar medium, indicating that the abundance of molecular oxygen is at least a factor of 10 to 100 lower than predicted by steady-state models.

Weaknesses

The major science goals for SWAS have been accomplished. While additional observations may add new sightlines and improved signal to noise, the potential for additional scientific breakthroughs is judged to be small.

Recommendation

We recommend that SWAS complete its primary mission and be granted the nine month no-cost extension. It appears that the mission can be terminated at that point with little scientific impact and need not go into an extended phase.

EUVE

The Extreme Ultraviolet Explorer (EUVE) has mapped the complete EUV sky, discovering over 1200 sources since its launch in 1992. During the pointed phase of the mission, over 700 individual targets have been observed. EUVE has experienced no significant degradation since launch. It is expected to reenter in May 2002. The project proposes a final Guest Observer program consisting exclusively of large (>0.5 Msec) coherent projects.

Strengths:

EUVE provides unique access to the 170-740Å band, encompassing the important intermediate ionization iron lines. There is also moderate resolution spectroscopy capability. It is a mature mission and can devote considerable time to individual projects.

The EUVE mission has pioneered several cost reduction techniques resulting in a total operations cost including proposal selection of ~$1.2 million per year, which is very low compared to most missions.

Weaknesses:

The potential for new discoveries with this mature mission is low. The science outlined in the sample projects of the proposed legacy program was not as compelling as other missions operating during the same time frame.

Recommendation

Now that the cross-calibration of the Chandra low energy grating spectrometer and the simultaneous Chandra/EUVE observations required for the Emission Line Project are complete, we concur with the 1998 Senior Review and recommend termination of operations.

VSOP

The 8-m diameter Japanese VSOP orbiting radio telescope is used together with the VLBA and other ground based radio telescopes to obtain high angular resolution radio imaging of quasars and AGN on a scale not achievable in any other wavelength band. The U. S. provides spacecraft tracking and correlation of the tapes from the space and ground radio telescopes needed for the operation of the mission.

Strengths

VSOP has demonstrated the feasibility of extending VLBI to earth-space baselines and has facilitated the organization of the ground-based infrastructure essential to planning the next generation of space VLBI missions. Planned long wavelength absorption observations will probe the accretion disks surrounding the putative black-holes in quasars and AGN as well as test the inverse Compton limit to the brightness temperature and the effect of Doppler boosting from highly relativistic jets.

Weaknesses

The range of scientific problems addressed by VSOP is limited. The loss of the 1.3 cm radiometer has compromised two of the key expectations of the mission to probe the central engines and jets of quasars and AGN and the structure of galactic and extragalactic H_20 masers with better resolution than the earth based VLBI networks. The cost effectiveness of the incremental new science resulting from extending the mission isn't clear.

Recommendation

An extension of mission support until the end of 2001 would permit a nearly complete additional cycle of observation, particularly of the key projects such as Cen A, M87, and 3C 273. An extension of MO&DA funding would be contingent on the availability of Code S funds and on continued Code M support.

AGILE

With the Compton Gamma Ray Observatory no longer in Earth orbit, a gap in astronomical coverage of the 10 MeV to 10 GeV energy range may persist until the Gamma-ray Large Area Space Telescope (GLAST) is placed in orbit around 2005. Mindful of this, the Italian Space Agency is building a small satellite, AGILE (Astro-rivelatore Gamma a Immagini Leggero), to fill a void left by the demise of the High-Energy Gamma-Ray Telescope (EGRET) on the Compton Observatory.

Scientists from the Goddard Space Flight Center and Columbia University have proposed to provide i) scientific support for this mission, including development of an improved interstellar gamma-ray model, an extended catalog of candidate point sources, multiwavelength observations and interpretive work; ii) software support, including sharing of techniques for gamma-ray rejection, and development of guest observer software; and iii) guest observer support, including establishment of a U.S. guest observer facility and a grants program for U.S. guest observers who submit successful AGILE observing proposals.

Strengths

AGILE would provide access to the gamma-ray portion of the spectrum similar to that provided by EGRET. The much wider field-of-view than EGRET makes AGILE an excellent instrument for studying high energy gamma-ray bursts and to identify and monitor flaring blazars.

Weaknesses

The work to be carried out by AGILE will be done better by the GLAST mission to which NASA is already committed. Further, the letter of Dr. Giovanni Bignami favoring “the joint development of [the above-cited] activities during the AGILE phase C/D, in preparation of a scientific program to be carried out within the AGILE Guest Observer Program,” lacks specific details on the return to the U.S. astronomical community for the support offered. The U.S. Guest Observer program is very small and limited. There is no clear commitment of data rights.

Recommendation

In view of the limited, interim scientific promise of AGILE, and the very limited opportunities for the broader U.S. astronomical community, we recommend that NASA not participate in this mission.

Data Centers

NED

The NASA/IPAC Extragalactic Database (NED) is an internet-based facility that supports the planning, execution, and publishing of research on problems in extragalactic astronomy and cosmology. It provides on-line electronic access to a database of galaxies, quasars, and extragalactic radio, x-ray, and infrared sources. The database contains positions, redshifts, photometry, images, other basic data, and associated physical quantities, as well as a comprehensive catalog of the peer-reviewed, published literature, and an extensive set of tools to support user interaction with the database.

Strengths

Since its inception, NED has become an irreplaceable tool for observational and archival extragalactic research. Searches by name, object type, redshift, position, or other parameters are used for planning observing programs as well as supporting data analyses. The ability to retrieve certain archived data (e.g. 2MASS) via NED is extremely valuable, as is the vetting of selected data, such as positions and redshifts. NED supplies all published data in detailed records, so that the researcher may evaluate various results him/herself.

The multiple points of entry (web-based, X-windows, and batch processing) are useful for users with various search requirements and access capabilities. The 'Level 5' introductory and review articles add a new dimension to NED, and will help students and others trying to review a particular area of astronomical research.

Weaknesses

The links between NED and some of the new large catalogs, such as those being produced by the US Naval Observatory, are poor.

Recommendation

This review ranked NED highly, and strongly recommends that NASA continue to support it. NED should concentrate on its core mission, i.e. cataloging extragalactic objects and the core associated data, with links to the published, refereed literature. New missions such as GALEX, SIRTF, and Chandra ensure that this will be a formidable task. NED should continue working with the astronomical journals to make the ingest of data into the database as automatic as possible.

Astrophysics Data System

Purpose

The Astrophysics Data System (ADS) is a unique data resource providing bibliographic information on a majority of astronomical publications to astronomers around the world. It provides abstracts for virtually all of these publications and actual on-line articles for many of them.

Strengths

The ADS is used by all astronomers and has become a vital part of astronomical research. The interface is fairly straightforward, allowing easy access and searches. The database of abstracts and on-line articles is extensive.

Weaknesses

Some articles and journals are not on-line, but we realize the difficulties of getting rights to do this. The usefulness of the book section is unclear.

Recommendation

We strongly recommend maintenance and updating of the abstract database. We recommend continued interaction with the AAS, other publishers, and other relevant databases (such as NED and SIMBAD) and archives (such as HEASARC, IRSA, and MAST) to develop relevant links, and common keywords and formats to facilitate more automated posting and links. The scanning and entry of historical publications (such as observatory reports) should be a lower priority. We recommend consideration of the inclusion of other on-line publications.

HEASARC

HEASARC is the High Energy Astrophysics Science Archival Research Center established by NASA in 1990. To date HEASARC holds the data from 20 observatories covering 30 years of X-ray and gamma-ray astronomy; the data center is used worldwide to download data and analysis software. In addition, HEASARC provides the users with the expertise required to fully exploit the data and software.

Strengths

HEASARC has provided excellent service to the worldwide astrophysics community for the last ten years. The archive has succeeded in ingesting and standardizing a large number of disparate data sets, and in providing easy access to these data together with very efficient analysis tools that uniquely enabled a wide spectrum of scientific projects, such as long-term monitoring and multi-wavelength studies of sources, surveys, etc. HEASARC has thus become absolutely essential in the community. It uses its MO&DA funding in a very efficient way.

The HEASARC personnel are responsive and helpful to the users; their service to the community is well appreciated and their scientific expertise amply used. The HEASARC leadership has been very successful and effective in acquiring current US and international mission data. HEASARC has developed a particularly innovative and very popular Education and Public Outreach (EPO) program.

Weaknesses

Multiwavelength interconnectivity is not optimal; some of the interfaces are moderately confusing (e.g., Argus).

Recommendation

We recommend (1) ingesting data from new missions, most importantly Chandra, as well as XMM and smaller missions (HETE-2), (2) improving software and search engines to achieve better interoperability with other (HEA and non-HEA) archives; and (3) coordinating further development of software with similar efforts of large data centers, such as Chandra, and XMM, to avoid duplications.

MAST

MAST, the Multi-mission Archive at the Space Telescope Science Institute, is NASA's optical/UV science archive center. Building on infrastructure provided for Hubble Space Telescope users, it has expanded these services to users of ten optical/infrared missions. Three of these, HST, EUVE, and FUSE are currently active. In addition, MAST provides archival services for the ground-based Digitized Sky Survey (scanned multi-band photographic plates taken at Schmidt telescopes in both hemispheres) and a VLA 20-centimeter wavelength radio sky survey. Exceeding 12 Terabytes, the MAST data holdings are among the largest astronomical collections currently available on line.

Strengths

The panel determined that MAST deserved high marks for quality of data contents, tools and services, and user friendliness and utility. While MAST, along with all the other data centers still has growing problems, its rapid evolution since inception in 1997 has been commendable.

Weaknesses

It is unclear how much further MAST should develop additional aids for users.

Recommendation

We recommend continued support for MAST.

IRSA

The InfraRed Science Archive (IRSA) is NASA's active archival research center for infrared mission data. Its major current holdings are the data from the IRAS, 2MASS, and MSX missions. Future plans include adding data from the ISO mission, the IRTS mission, SOFIA, SIRTF, COBE, and other cosmic microwave background data sets.

Strengths

IRSA has initially concentrated on developing the capability to do data mining on large area sky surveys. This center has already developed critical capabilities for utilizing the huge 2MASS data base for research, including serving as an interface to the 200 Gigabyte image atlas and providing statistical analysis tools for dealing with the large catalog. Users generally find the tools well-designed and easy to use.

Weaknesses

The connection and interoperability of IRSA with other data centers is still rather modest. IRSA has yet to provide observation planning support and efficient target-based archive services comparable to those at the other astrophysics discipline archive centers. Costs for computing facilities and the overall proposed baseline cost are high relative to the other NASA data centers.

Recommendation

The importance of the existing and future infrared data sets justifies continued support of the infrared archive center. IRSA should concentrate on ingesting the rest of the 2MASS and the ISO data sets and providing the support to make these data accessible to the community.

ADC - Astrophysics at NSSDC

The National Space Science Data Center (NSSDC) provides a permanent archive for astrophysical data and an active archive for some astrophysics missions, and operates the Astronomical Data Center (ADC). ADC, which was established to support the collection and distribution of computerized astronomical catalogs and other tabulated measurements, belongs to a network of international astronomical data centers, with the Strasbourg Data Center (CDS) as the hub.

Strengths

The NSSDC currently archives 4.2 Terrabytes of astrophysical data from about 30 missions. This is done satisfactorily and with apparent care.

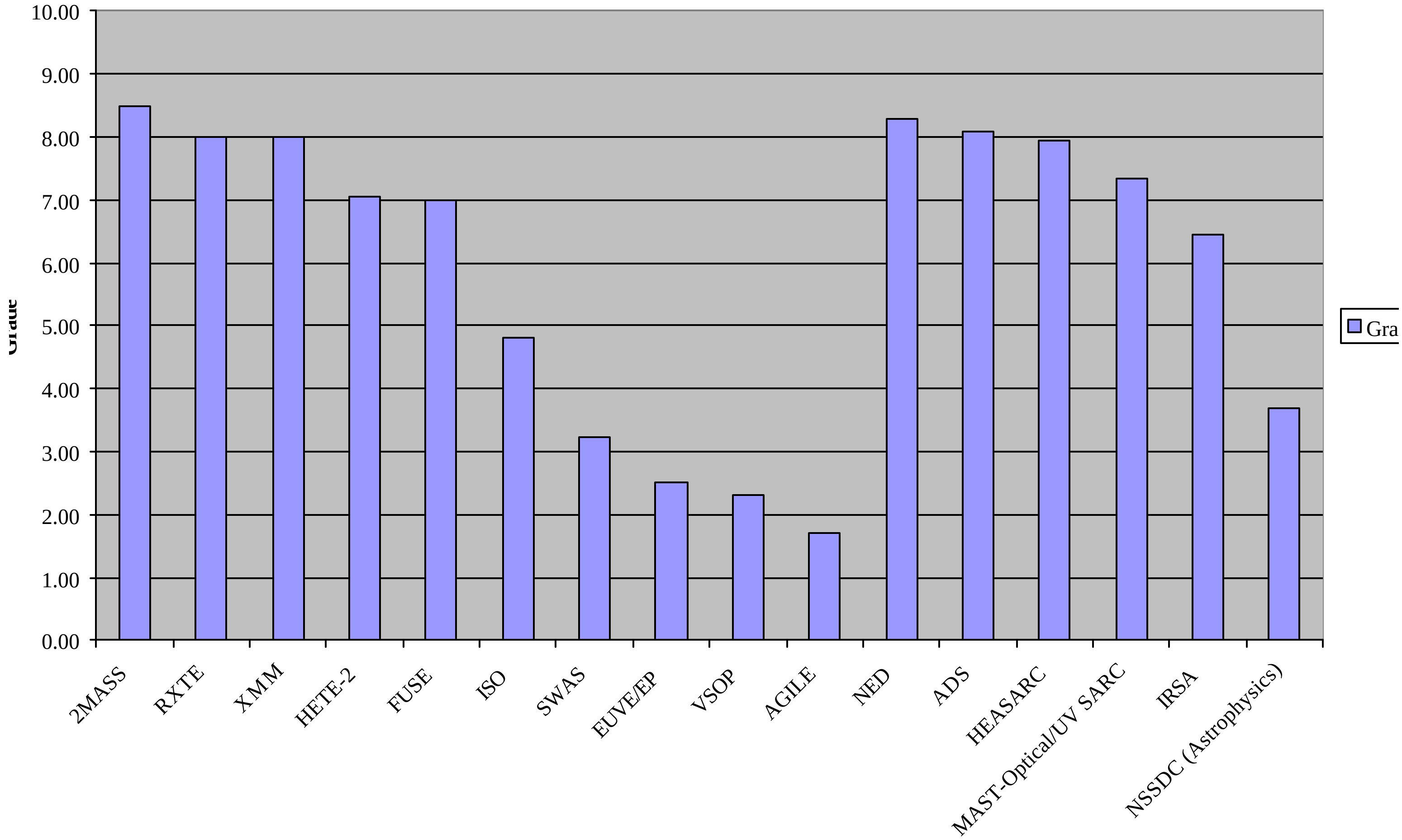
Weaknesses

The NSSDC needs to work more closely with other data centers, especially in connectivity and active linking. Tabular holdings, although useful, are not widely used.

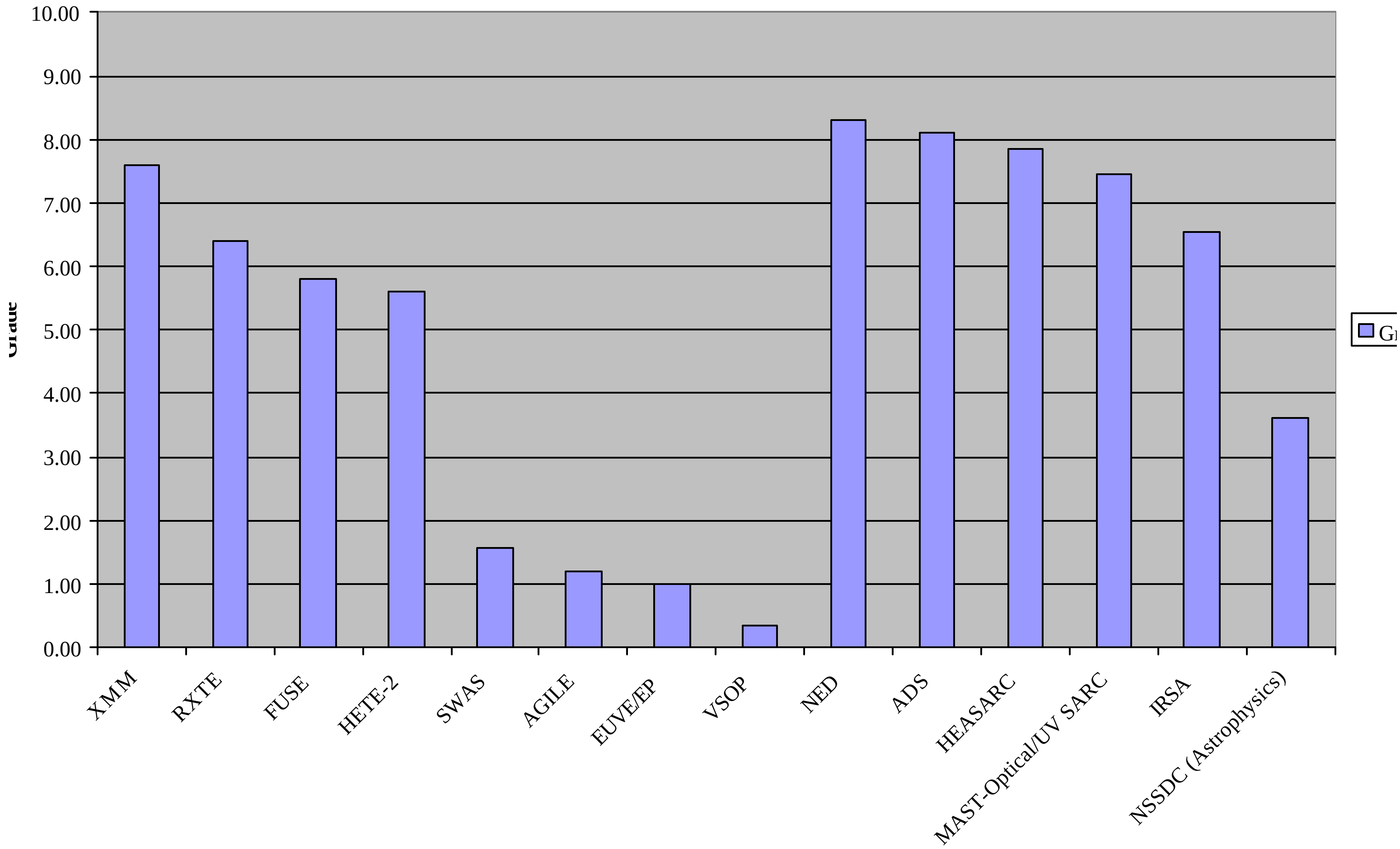
Recommendation

The panel recommends a review of the functions of NSSDC and NASA's other data centers with a view to sorting out their overlapping responsibilities and redirecting their activities to streamline the agency's overall data storage, archiving, and handling functions.

Science Grades for Missions and Science/Data Services FY01-02



Science Grades for Missions and Science/Data Services FY03-04



Acronym List

AAS	American Astronomical Society
ADC	Astronomical Data Center
ADS	Astrophysics Data System
AGILE	Astro-Rivelatore Gamma a Immagini Leggero
AGN	Active Galactic Nuclei
Cal/PV	Calibration/Performance Verification
CDS	Strasbourg Data Center
COBE	Cosmic Background Explorer
EGRET	Energetic Gamma-Ray Telescope
EPIC	European Photon Imaging Camera
EPO	Education and Public Outreach
ESA	European Space Agency
EUV	Extreme Ultraviolet
EUVE	Extreme Ultraviolet Explorer
FUSE	Far Ultraviolet Spectroscopic Explorer
GALEX	Galaxy Evolution Explorer
GLAST	Gamma-Ray Large Area Space Telescope
GOF	Guest Observer Facility
GRBs	Gamma-Ray Bursts
GTO	Guaranteed Time Observer
HEA	High Energy Astrophysics
HEASARC	High Energy Astrophysics Science Archival Research Center
HETE-2	High Energy Transient Experiment
IGM	Intergalactic Medium
IPAC	Infrared Processing and Analysis Center
IRAS	Infrared Astronomical Satellite
IRSA	Infrared Science Archive
IRTS	Infrared Telescope System?
ISM	Interstellar Medium
ISO	Infrared Space Observatory
ISOPHOT	ISO Photometer
MAP	Microwave Anisotropy Probe
MAST	Multi-Mission Archive at the Space Telescope
MIDEX	Medium Explorer
MO&DA	Mission Operations And Data Analysis
MSX	Mid-deck Space Experiment
NED	NASA/IPAC Extragalactic Database
NGST	Next Generation Space Telescope
NSSDC	National Space Science Data Center
NVO	National Virtual Observatory
PCA	Proportional Counter Array
QPO	Quasi-Periodic Oscillatior

RGS	Reflection Grating Spectrometer
RXTE	Rossi X-ray Timing Explorer
SIMBAD	Set of Identification, Measurements & Bibliography for Astronomical Data
SIRTF	Space Infrared Telescope Facility
SOFIA	Stratospheric Observatory for Infrared Astronomy
SWAS	Submillimeter Wave Astronomy Satellite
VLBI	Very Long Baseline Interferometry
VSOP	VLBI Space Observatory Program
XMM	X-ray Multi-Mirror [Telescope] Mission
2MASS	Two-Micron All Sky Survey